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Arrival
the book

Ted Chiang

Arrival

Your father is about to ask me the question. This is the most important moment in our lives, and I want to pay attention, note every detail. Your dad and I have just come back from an evening out, dinner and a show; it's after midnight. We came out onto the patio to look at the full moon; then I told your dad I wanted to dance, so he humors me and now we're slow dancing, a pair of thirty somethings swaying back and forth in the moonlight like kids. I don't feel the night chill at all. And then your dad says, "Do you want to make a baby?"

Right now your dad and I have been married for about two years, living on Ellis Avenue; when we move out you'll still be too young to remember the house, but we'll show you pictures of it, tell you stories about it. I'd love to tell you the story of this evening, the night you're conceived, but the right time to do that would be when you're ready to have children of your own, and we'll never get that chance.

Telling it to you any earlier wouldn't do any good; for most of your life you won't sit still to hear such a romantic— you'd say sappy— story. I remember the scenario of your origin you'll suggest when you're twelve.

"The only reason you had me was so you could get a maid you wouldn't have to pay," you'll say bitterly, dragging the vacuum cleaner out of the closet.

"That's right," I'll say. "Thirteen years ago I knew the carpets would need vacuuming around now, and having a baby seemed to be the cheapest and easiest way to get the job done. Now kindly get on with it."

"If you weren't my mother, this would be illegal," you'll say, seething as you unwind the power cord and plug it into the wall outlet.

That will be in the house on Belmont Street. I'll live to see strangers occupy both houses: the one you're conceived in and the one you grow up in. Your dad and I will sell the first a couple years after your arrival. I'll sell the second shortly after your departure. By then Nelson and I will have moved into our farmhouse, and your dad will be living with what's-her-name.

I know how this story ends; I think about it a lot. I also think a lot about how it began, just a few years ago, when ships appeared in orbit and artifacts appeared in meadows. The government said next to nothing about them, while the tabloids said every possible thing.

And then I got a phone call, a request for a meeting.

• • •

I spotted them waiting in the hallway, outside my office. They made an odd couple; one wore a military uniform and a crew cut, and carried an aluminum briefcase. He seemed to be assessing his surroundings with a critical eye. The other one was easily identifiable as an academic: full beard and mustache, wearing corduroy. He was browsing through the overlapping sheets stapled to a bulletin board nearby.

"Colonel Weber, I presume?" I shook hands with the soldier. "Louise Banks."

"Dr. Banks. Thank you for taking the time to speak with us," he said.

"Not at all; any excuse to avoid the faculty meeting." Colonel Weber indicated his companion. "This is Dr. Gary Donnelly, the physicist I mentioned when we spoke on the phone."

"Call me Gary," he said as we shook hands. "I'm anxious to hear what you have to say."

We entered my office. I moved a couple of stacks of books off the second guest chair, and we all sat down. "You said you wanted me to listen to a recording. I presume this has something to do with the aliens?"

"All I can offer is the recording," said Colonel Weber.

"Okay, let's hear it."

Colonel Weber took a tape machine out of his briefcase and pressed play. The recording sounded vaguely like that of a wet dog shaking the water out of its fur.

"What do you make of that?" he asked.

I withheld my comparison to a wet dog. "What was the context in which this recording was made?"

"I'm not at liberty to say."

"It would help me interpret those sounds. Could you see the alien while it was speaking? Was it doing anything at the time?"

"The recording is all I can offer."

"You won't be giving anything away if you tell me that you've seen the aliens; the public's assumed you have."

Colonel Weber wasn't budging. "Do you have any opinion about its linguistic properties?" he asked.

"Well, it's clear that their vocal tract is substantially different from a human vocal tract. I assume that these aliens don't look like

humans?"

The colonel was about to say something noncommittal when Gary Donelly asked, "Can you make any guesses based on the tape?"

"Not really. It doesn't sound like they're using a larynx to make those sounds, but that doesn't tell me what they look like."

"Anything— is there anything else you can tell us?" asked Colonel Weber.

I could see he wasn't accustomed to consulting a civilian. "Only that establishing communications is going to be really difficult because of the difference in anatomy. They're almost certainly using sounds that the human vocal tract can't reproduce, and maybe sounds that the human ear can't distinguish."

"You mean infra-or ultrasonic frequencies?" asked Gary Donelly.

"Not specifically. I just mean that the human auditory system isn't an absolute acoustic instrument; it's optimized to recognize the sounds that a human larynx makes. With an alien vocal system, all bets are off." I shrugged. "*Maybe* we'll be able to hear the difference between alien phonemes, given enough practice, but it's possible our ears simply can't recognize the distinctions they consider meaningful. In that case we'd need a sound spectrograph to know what an alien is saying."

Colonel Weber asked, "Suppose I gave you an hour's worth of recordings; how long would it take you to determine if we need this sound spectrograph or not?"

"I couldn't determine that with just a recording no matter how much time I had. I'd need to talk with the aliens directly."

The colonel shook his head. "Not possible."

I tried to break it to him gently. "That's your call, of course. But the only way to learn an unknown language is to interact with a native speaker, and by that I mean asking questions, holding a conversation, that sort of thing. Without that, it's simply not possible. So if you want to learn the aliens' language, someone with training in field linguistics— whether it's me or someone else— will have to talk with an alien. Recordings alone aren't sufficient."

Colonel Weber frowned. "You seem to be implying that no alien could have learned human languages by monitoring our broadcasts."

"I doubt it. They'd need instructional material specifically designed to teach human languages to nonhumans. Either that, or interaction with a human. If they had either of those, they could learn a lot from TV, but otherwise, they wouldn't have a starting point."

The colonel clearly found this interesting; evidently his philosophy was, the less the aliens knew, the better. Gary Donnelly read the colonel's expression too and rolled his eyes. I suppressed a smile.

Then Colonel Weber asked, "Suppose you were learning a new language by talking to its speakers; could you do it without teaching them English?"

"That would depend on how cooperative the native speakers were. They'd almost certainly pick up bits and pieces while I'm learning their language, but it wouldn't have to be much if they're willing to teach. On the other hand, if they'd rather learn English than teach us their language, that would make things far more difficult."

The colonel nodded. "I'll get back to you on this matter."

• • •

The request for that meeting was perhaps the second most momentous phone call in my life. The first, of course, will be the one from Mountain Rescue. At that point your dad and I will be speaking to each other maybe once a year, tops. After I get that phone call, though, the first thing I'll do will be to call your father.

He and I will drive out together to perform the identification, a long silent car ride. I remember the morgue, all tile and stainless steel, the hum of refrigeration and smell of antiseptic. An orderly will pull the sheet back to reveal your face. Your face will look wrong somehow, but I'll know it's you.

"Yes, that's her," I'll say. "She's mine."

You'll be twenty-five then.

• • •

The MP checked my badge, made a notation on his clipboard, and opened the gate; I drove the off-road vehicle into the encampment, a small village of tents pitched by the Army in a farmer's sun-scorched pasture. At the center of the encampment was one of the alien devices, nicknamed "looking glasses."

According to the briefings I'd attended, there were nine of these in the United States, one hundred and twelve in the world. The looking glasses acted as two-way communication devices, presumably with the ships in orbit. No one knew why the aliens wouldn't talk to us in person; fear of cooties, maybe. A team of scientists, including a physicist and a linguist, was assigned to each looking glass; Gary Donnelly and I were on this one.

Gary was waiting for me in the parking area. We navigated a circular maze of concrete barricades until we reached the large tent that covered the looking glass itself. In front of the tent was an equipment

cart loaded with goodies borrowed from the school's phonology lab; I had sent it ahead for inspection by the Army.

Also outside the tent were three tripod-mounted video cameras whose lenses peered, through windows in the fabric wall, into the main room. Everything Gary and I did would be reviewed by countless others, including military intelligence. In addition we would each send daily reports, of which mine had to include estimates on how much English I thought the aliens could understand.

Gary held open the tent flap and gestured for me to enter. "Step right up," he said, circus barker— style. "Marvel at creatures the likes of which have never been seen on God's green earth."

"And all for one slim dime," I murmured, walking through the door. At the moment the looking glass was inactive, resembling a semicircular mirror over ten feet high and twenty feet across. On the brown grass in front of the looking glass, an arc of white spray paint outlined the activation area. Currently the area contained only a table, two folding chairs, and a power strip with a cord leading to a generator outside. The buzz of fluorescent lamps, hung from poles along the edge of the room, commingled with the buzz of flies in the sweltering heat.

Gary and I looked at each other, and then began pushing the cart of equipment up to the table. As we crossed the paint line, the looking glass appeared to grow transparent; it was as if someone was slowly raising the illumination behind tinted glass. The illusion of depth was uncanny; I felt I could walk right into it. Once the looking glass was fully lit it resembled a life-size diorama of a semicircular room. The room contained a few large objects that might have been furniture, but no aliens. There was a door in the curved rear wall.

We busied ourselves connecting everything together: microphone, sound spectrograph, portable computer, and speaker. As we worked, I frequently glanced at the looking glass, anticipating the aliens' arrival. Even so I jumped when one of them entered.

It looked like a barrel suspended at the intersection of seven limbs. It was radially symmetric, and any of its limbs could serve as an arm or a leg. The one in front of me was walking around on four legs, three non-adjacent arms curled up at its sides. Gary called them "heptapods."

I'd been shown videotapes, but I still gawked. Its limbs had no distinct joints; anatomists guessed they might be supported by vertebral columns. Whatever their underlying structure, the heptapod's limbs conspired to move it in a disconcertingly fluid manner. Its "torso" rode atop the rippling limbs as smoothly as a hovercraft.

Seven lidless eyes ringed the top of the heptapod's body. It walked back to the doorway from which it entered, made a brief sputtering sound, and returned to the center of the room followed by another heptapod; at no point did it ever turn around. Eerie, but logical; with eyes on all sides, any direction might as well be "forward."

Gary had been watching my reaction. "Ready?" he asked.

I took a deep breath. "Ready enough." I'd done plenty of fieldwork before, in the Amazon, but it had always been a bilingual procedure: either my informants knew some Portuguese, which I could use, or I'd previously gotten an intro to their language from the local missionaries. This would be my first attempt at conducting a true monolingual discovery procedure. It was straightforward enough in theory, though.

I walked up to the looking glass and a heptapod on the other side did the same. The image was so real that my skin crawled. I could see the texture of its gray skin, like corduroy ridges arranged in whorls and loops. There was no smell at all from the looking glass, which somehow made the situation stranger.

I pointed to myself and said slowly, "Human." Then I pointed to Gary. "Human." Then I pointed at each heptapod and said, "What are you?"

No reaction. I tried again, and then again.

One of the heptapods pointed to itself with one limb, the four terminal digits pressed together. That was lucky. In some cultures a person pointed with his chin; if the heptapod hadn't used one of its limbs, I wouldn't have known what gesture to look for. I heard a brief fluttering sound, and saw a puckered orifice at the top of its body vibrate; it was talking. Then it pointed to its companion and fluttered again.

I went back to my computer; on its screen were two virtually identical spectrographs representing the fluttering sounds. I marked a sample for playback. I pointed to myself and said "Human" again, and did the same with Gary. Then I pointed to the heptapod, and played back the flutter on the speaker.

The heptapod fluttered some more. The second half of the spectrograph for this utterance looked like a repetition: call the previous utterances [flutter1], then this one was [flutter2-flutter1].

I pointed at something that might have been a heptapod chair. "What is that?"

The heptapod paused, and then pointed at the "chair" and talked some more. The spectrograph for this differed distinctly from that of the earlier sounds: [flutter3]. Once again, I pointed to the "chair" while playing back [flutter3].

The heptapod replied; judging by the spectrograph, it looked like [flutter3flutter2]. Optimistic interpretation: the heptapod was confirming my utterances as correct, which implied compatibility between heptapod and human patterns of discourse. Pessimistic interpretation: it had a nagging cough.

At my computer I delimited certain sections of the spectrograph and typed in a tentative gloss for each: "heptapod" for [flutter1], "yes" for [flutter2], and "chair" for [flutter3]. Then I typed "Language: Heptapod A" as a heading for all the utterances.

Gary watched what I was typing. "What's the 'A' for?"

"It just distinguishes this language from any other ones the heptapods might use," I said. He nodded.

"Now let's try something, just for laughs." I pointed at each heptapod and tried to mimic the sound of [flutter1], "heptapod." After a long pause, the first heptapod said something and then the second one said something else, neither of whose spectrographs resembled anything said before. I couldn't tell if they were speaking to each other or to me since they had no faces to turn. I tried pronouncing [flutter1] again, but there was no reaction.

"Not even close," I grumbled.

"I'm impressed you can make sounds like that at all," said Gary.

"You should hear my moose call. Sends them running."

I tried again a few more times, but neither heptapod responded with anything I could recognize. Only when I replayed the recording of the heptapod's pronunciation did I get a confirmation; the heptapod replied with [flutter2], "yes."

"So we're stuck with using recordings?" asked Gary.

I nodded. "At least temporarily."

"So now what?"

"Now we make sure it hasn't actually been saying 'aren't they cute' or 'look what they're doing now.' Then we see if we can identify any of these words when that other heptapod pronounces them." I gestured for him to have a seat. "Get comfortable; this'll take a while."

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In 1770, Captain Cook's ship *Endeavour* ran aground on the coast of Queensland, Australia. While some of his men made repairs, Cook led an exploration party and met the aboriginal people. One of the sailors pointed to the animals that hopped around with their young riding in pouches, and asked an aborigine what they were called. The aborigine replied, "Kanguru." From then on Cook and his sailors referred to the animals by this word. It wasn't until later that they learned it meant "What did you say?"

I tell that story in my introductory course every year. It's almost certainly untrue, and I explain that afterwards, but it's a classic anecdote. Of course, the anecdotes my undergraduates will really want to hear are ones featuring the heptapods; for the rest of my teaching career, that'll be the reason many of them sign up for my courses. So I'll show them the old videotapes of my sessions at the looking glass, and the sessions that the other linguists conducted; the tapes are instructive, and they'll be useful if we're ever visited by aliens again, but they don't generate many good anecdotes.

When it comes to language-learning anecdotes, my favorite source is child language acquisition. I remember one afternoon when you are five years old, after you have come home from kindergarten. You'll be coloring with your crayons while I grade papers.

"Mom," you'll say, using the carefully casual tone reserved for requesting a favor, "can I ask you something?"

"Sure, sweetie. Go ahead."

"Can I be, um, honored?"

I'll look up from the paper I'm grading. "What do you mean?"

"At school Sharon said she got to be honored."

"Really? Did she tell you what for?"

"It was when her big sister got married. She said only one person could be, um, honored, and she was it."

"Ah, I see. You mean Sharon was maid of honor?"

"Yeah, that's it. Can I be made of honor?"

• • •

Gary and I entered the prefab building containing the center of operations for the looking glass site. Inside it looked like they were planning an invasion, or perhaps an evacuation: crewcut soldiers worked around a large map of the area, or sat in front of burly electronic gear while speaking into headsets. We were shown into Colonel Weber's office, a room in the back that was cool from air conditioning.

We briefed the colonel on our first day's results. "Doesn't sound like you got very far," he said.

"I have an idea as to how we can make faster progress," I said. "But you'll have to approve the use of more equipment."

"What more do you need?"

"A digital camera, and a big video screen." I showed him a drawing of the setup I imagined. "I want to try conducting the discovery procedure using writing; I'd display words on the screen, and use the camera to record the words they write. I'm hoping the heptapods will do the same."

Weber looked at the drawing dubiously. "What would be the advantage of that?"

"So far I've been proceeding the way I would with speakers of an unwritten language. Then it occurred to me that the heptapods must have writing, too."

"So?"

"If the heptapods have a mechanical way of producing writing, then their writing ought to be very regular, very consistent. That would make it easier for us to identify graphemes instead of phonemes. It's like picking out the letters in a printed sentence instead of trying to hear them when the sentence is spoken aloud."

"I take your point," he admitted. "And how would you respond to them? Show them the words they displayed to you?"

"Basically. And if they put spaces between words, any sentences we write would be a lot more intelligible than any spoken sentence we might splice together from recordings."

He leaned back in his chair. "You know we want to show as little of our technology as possible."

"I understand, but we're using machines as intermediaries already. If we can get them to use writing, I believe progress will go much faster than if we're restricted to the sound spectrographs."

The colonel turned to Gary. "Your opinion?"

"It sounds like a good idea to me. I'm curious whether the heptapods might have difficulty reading our monitors. Their looking glasses are based on a completely different technology than our video screens. As far as we can tell, they don't use pixels or scan lines, and they don't refresh on a frame-by-frame basis."

"You think the scan lines on our video screens might render them unreadable to the heptapods?"

"It's possible," said Gary. "We'll just have to try it and see."

Weber considered it. For me it wasn't even a question, but from his point of view it was a difficult decision; like a soldier, though, he made it quickly. "Request granted. Talk to the sergeant outside about bringing in what you need. Have it ready for tomorrow."

• • •

I remember one day during the summer when you're sixteen. For once, the person waiting for her date to arrive is me. Of course, you'll be waiting around too, curious to see what he looks like. You'll have a friend of yours, a blond girl with the unlikely name of Roxie, hanging out with you, giggling.

"You may feel the urge to make comments about him," I'll say, checking myself in the hallway mirror. "Just restrain yourselves until we leave."

"Don't worry, Mom," you'll say. "We'll do it so that he won't know. Roxie, you ask me what I think the weather will be like tonight. Then I'll say what I think of Mom's date."

"Right," Roxie will say.

"No, you most definitely will not," I'll say.

"Relax, Mom. He'll never know; we do this all the time."

"What a comfort that is."

A little later on, Nelson will arrive to pick me up. I'll do the introductions, and we'll all engage in a little small talk on the front porch. Nelson is ruggedly handsome, to your evident approval. Just as we're about to leave, Roxie will say to you casually, "So what do you think the weather will be like tonight?"

"I think it's going to be really hot," you'll answer.

Roxie will nod in agreement. Nelson will say, "Really? I thought they said it was going to be cool."

"I have a sixth sense about these things," you'll say. Your face will give nothing away. "I get the feeling it's going to be a scorcher. Good thing you're dressed for it, Mom."

I'll glare at you, and say good night.

As I lead Nelson toward his car, he'll ask me, amused, "I'm missing something here, aren't I?"

"A private joke," I'll mutter. "Don't ask me to explain it."

• • •

At our next session at the looking glass, we repeated the procedure we had performed before, this time displaying a printed word on our computer screen at the same time we spoke: showing human while saying "Human," and so forth. Eventually, the heptapods understood what we wanted, and set up a flat circular screen mounted on a small pedestal. One heptapod spoke, and then inserted a limb into a

large socket in the pedestal; a doodle of script, vaguely cursive, popped onto the screen.

We soon settled into a routine, and I compiled two parallel corpora: one of spoken utterances, one of writing samples. Based on first impressions, their writing appeared to be logo-graphic, which was disappointing; I'd been hoping for an alphabetic script to help us learn their speech. Their logograms might include some phonetic information, but finding it would be a lot harder than with an alphabetic script.

By getting up close to the looking glass, I was able to point to various heptapod body parts, such as limbs, digits, and eyes, and elicit terms for each. It turned out that they had an orifice on the underside of their body, lined with articulated bony ridges: probably used for eating, while the one at the top was for respiration and speech. There were no other conspicuous orifices; perhaps their mouth was their anus too. Those sorts of questions would have to wait.

I also tried asking our two informants for terms for addressing each individually; personal names, if they had such things. Their answers were of course unpronounceable, so for Gary's and my purposes, I dubbed them Flapper and Raspberry. I hoped I'd be able to tell them apart.

...

The next day I conferred with Gary before we entered the looking-glass tent. "I'll need your help with this session," I told him.

"Sure. What do you want me to do?"

"We need to elicit some verbs, and it's easiest with third-person forms. Would you act out a few verbs while I type the written form on the computer? If we're lucky, the heptapods will figure out what we're

doing and do the same. I've brought a bunch of props for you to use."

"No problem," said Gary, cracking his knuckles. "Ready when you are."

We began with some simple intransitive verbs: walking, jumping, speaking, writing. Gary demonstrated each one with a charming lack of self-consciousness; the presence of the video cameras didn't inhibit him at all. For the first few actions he performed, I asked the heptapods, "What do you call that?" Before long, the heptapods caught on to what we were trying to do; Raspberry began mimicking Gary, or at least performing the equivalent heptapod action, while Flapper worked their computer, displaying a written description and pronouncing it aloud.

In the spectrographs of their spoken utterances, I could recognize their word I had glossed as "heptapod." The rest of each utterance was presumably the verb phrase; it looked like they had analogs of nouns and verbs, thank goodness.

In their writing, however, things weren't as clear-cut. For each action, they had displayed a single logogram instead of two separate ones. At first I thought they had written something like "walks," with the subject implied. But why would Flapper say "the heptapod walks" while writing "walks," instead of maintaining parallelism? Then I noticed that some of the logograms looked like the logogram for "heptapod" with some extra strokes added to one side or another. Perhaps their verbs could be written as affixes to a noun. If so, why was Flapper writing the noun in some instances but not in others?

I decided to try a transitive verb; substituting object words might clarify things. Among the props I'd brought were an apple and a slice of bread. "Okay," I said to Gary, "show them the food, and then eat some. First the apple, then the bread."

Gary pointed at the Golden Delicious and then he took a bite out of it, while I displayed the "what do you call that?" expression. Then we repeated it with the slice of whole wheat.

Raspberry left the room and returned with some kind of giant nut or gourd and a gelatinous ellipsoid. Raspberry pointed at the gourd while Flapper said a word and displayed a logogram. Then Raspberry brought the gourd down between its legs, a crunching sound resulted, and the gourd reemerged minus a bite; there were corn-like kernels beneath the shell. Flapper talked and displayed a large logogram on their screen. The sound spectrograph for "gourd" changed when it was used in the sentence; possibly a case marker. The logogram was odd: after some study, I could identify graphic elements that resembled the individual logograms for "heptapod" and "gourd." They looked as if they had been melted together, with several extra strokes in the mix that presumably meant "eat." Was it a multi-word ligature?

Next we got spoken and written names for the gelatin egg, and descriptions of the act of eating it. The sound spectrograph for "heptapod eats gelatin egg" was analyzable; "gelatin egg" bore a case marker, as expected, though the sentence's word order differed from last time. The written form, another large logogram, was another matter. This time it took much longer for me to recognize anything in it; not only were the individual logograms melted together again, it looked as if the one for "heptapod" was laid on its back, while on top of it the logogram for "gelatin egg" was standing on its head.

"Uh-oh." I took another look at the writing for the simple noun-verb examples, the ones that had seemed inconsistent before. Now I realized all of them actually did contain the logogram for "heptapod"; some were rotated and distorted by being combined with the various verbs, so I hadn't recognized them at first. "You guys have got to be kidding," I muttered.

"What's wrong?" asked Gary.

"Their script isn't word divided; a sentence is written by joining the logograms for the constituent words. They join the logograms by rotating and modifying them. Take a look." I showed him how the logograms were rotated.

"So they can read a word with equal ease no matter how it's rotated," Gary said. He turned to look at the heptapods, impressed. "I wonder if it's a consequence of their bodies' radial symmetry: their bodies have no 'forward' direction, so maybe their writing doesn't either. Highly neat."

I couldn't believe it; I was working with someone who modified the word "neat" with "highly." "It certainly is interesting," I said, "but it also means there's no easy way for us to write our own sentences in their language. We can't simply cut their sentences into individual words and recombine them; we'll have to learn the rules of their script before we can write anything legible. It's the same continuity problem we'd have had splicing together speech fragments, except applied to writing."

I looked at Flapper and Raspberry in the looking glass, who were waiting for us to continue, and sighed. "You aren't going to make this easy for us, are you?"

...

To be fair, the heptapods were completely cooperative. In the days that followed, they readily taught us their language without requiring us to teach them any more English. Colonel Weber and his cohorts pondered the implications of that, while I and the linguists at the other looking glasses met via videoconferencing to share what we had learned about the heptapod language. The videoconferencing made for an incongruous working environment: our video screens were primitive compared to the heptapods' looking glasses, so that

my colleagues seemed more remote than the aliens. The familiar was far away, while the bizarre was close at hand.

It would be a while before we'd be ready to ask the heptapods why they had come, or to discuss physics well enough to ask them about their technology. For the time being, we worked on the basics: phonemics/graphemics, vocabulary, syntax. The heptapods at every looking glass were using the same language, so we were able to pool our data and coordinate our efforts.

Our biggest source of confusion was the heptapods' "writing." It didn't appear to be writing at all; it looked more like a bunch of intricate graphic designs. The logograms weren't arranged in rows, or a spiral, or any linear fashion. Instead, Flapper or Raspberry would write a sentence by sticking together as many logograms as needed into a giant conglomeration.

This form of writing was reminiscent of primitive sign systems, which required a reader to know a message's context in order to understand it. Such systems were considered too limited for systematic recording of information. Yet it was unlikely that the heptapods developed their level of technology with only an oral tradition. That implied one of three possibilities: the first was that the heptapods had a true writing system, but they didn't want to use it in front of us; Colonel Weber would identify with that one. The second was that the heptapods hadn't originated the technology they were using; they were illiterates using someone else's technology. The third, and most interesting to me, was that was the heptapods were using a nonlinear system of orthography that qualified as true writing.

• • •

I remember a conversation we'll have when you're in your junior year of high school. It'll be Sunday morning, and I'll be scrambling some

eggs while you set the table for brunch. You'll laugh as you tell me about the party you went to last night.

"Oh man," you'll say, "they're not kidding when they say that body weight makes a difference. I didn't drink any more than the guys did, but I got so much *drunker*."

I'll try to maintain a neutral, pleasant expression. I'll really try. Then you'll say, "Oh, come on, Mom."

"What?"

"You know you did the exact same things when you were my age."

I did nothing of the sort, but I know that if I were to admit that, you'd lose respect for me completely. "You know never to drive, or get into a car if—"

"God, of course I know that. Do you think I'm an idiot?"

"No, of course not."

What I'll think is that you are clearly, maddeningly not me. It will remind me, again, that you won't be a clone of me; you can be wonderful, a daily delight, but you won't be someone I could have created by myself.

...

The military had set up a trailer containing our offices at the looking glass site. I saw Gary walking toward the trailer, and ran to catch up with him. "It's a semasiographic writing system," I said when I reached him.

"Excuse me?" said Gary.

"Here, let me show you." I directed Gary into my office. Once we were inside, I went to the chalkboard and drew a circle with a diagonal line bisecting it. "What does this mean?"

" 'Not allowed'?"

"Right." Next I printed the words not allowed on the chalkboard. "And so does this. But only one is a representation of speech."

Gary nodded. "Okay."

"Linguists describe writing like this"— I indicated the printed words—"as 'glottographic,' because it represents speech. Every human written language is in this category. However, this symbol"— I indicated the circle and diagonal line—"is 'semasiographic' writing, because it conveys meaning without reference to speech. There's no correspondence between its components and any particular sounds."

"And you think all of heptapod writing is like this?"

"From what I've seen so far, yes. It's not picture writing, it's far more complex. It has its own system of rules for constructing sentences, like a visual syntax that's unrelated to the syntax for their spoken language."

"A visual syntax? Can you show me an example?"

"Coming right up." I sat down at my desk and, using the computer, pulled up a frame from the recording of yesterday's conversation with Raspberry. I turned the monitor so he could see it. "In their spoken language, a noun has a case marker indicating whether it's a subject or object. In their written language, however, a noun is identified as subject or object based on the orientation of its logogram relative to that of the verb. Here, take a look." I pointed at one of the figures. "For instance, when 'heptapod' is integrated with

'hears' this way, with these strokes parallel, it means that the heptapod is doing the hearing." I showed him a different one. "When they're combined this way, with the strokes perpendicular, it means that the heptapod is being heard. This morphology applies to several verbs.

"Another example is the inflection system." I called up another frame from the recording. "In their written language, this logogram means roughly 'hear easily' or 'hear clearly.' See the elements it has in common with the logogram for 'hear'? You can still combine it with 'heptapod' in the same ways as before, to indicate that the heptapod can hear something clearly or that the heptapod is clearly heard. But what's really interesting is that the modulation of 'hear' into 'hear clearly' isn't a special case; you see the transformation they applied?"

Gary nodded, pointing. "It's like they express the idea of 'clearly' by changing the curve of those strokes in the middle."

"Right. That modulation is applicable to lots of verbs. The logogram for 'see' can be modulated in the same way to form 'see clearly,' and so can the logogram for 'read' and others. And changing the curve of those strokes has no parallel in their speech; with the spoken version of these verbs, they add a prefix to the verb to express ease of manner, and the prefixes for 'see' and 'hear' are different.

"There are other examples, but you get the idea. It's essentially a grammar in two dimensions."

He began pacing thoughtfully. "Is there anything like this in human writing systems?"

"Mathematical equations, notations for music and dance. But those are all very specialized; we couldn't record this conversation using them. But I suspect, if we knew it well enough, we could record this conversation in the heptapod writing system. I think it's a full-fledged, general-purpose graphical language."

Gary frowned. "So their writing constitutes a completely separate language from their speech, right?"

"Right. In fact, it'd be more accurate to refer to the writing system as 'Heptapod B,' and use 'Heptapod A' strictly for referring to the spoken language."

"Hold on a second. Why use two languages when one would suffice? That seems unnecessarily hard to learn."

"Like English spelling?" I said. "Ease of learning isn't the primary force in language evolution. For the heptapods, writing and speech may play such different cultural or cognitive roles that using separate languages makes more sense than using different forms of the same one."

He considered it. "I see what you mean. Maybe they think our form of writing is redundant, like we're wasting a second communications channel."

"That's entirely possible. Finding out why they use a second language for writing will tell us a lot about them."

"So I take it this means we won't be able to use their writing to help us learn their spoken language."

I sighed. "Yeah, that's the most immediate implication. But I don't think we should ignore either Heptapod A or B; we need a two-pronged approach." I pointed at the screen. "I'll bet you that learning their two-dimensional grammar will help you when it comes time to learn their mathematical notation."

"You've got a point there. So are we ready to start asking about their mathematics?"

"Not yet. We need a better grasp on this writing system before we begin anything else," I said, and then smiled when he mimed frustration. "Patience, good sir. Patience is a virtue."

...

You'll be six when your father has a conference to attend in Hawaii, and we'll accompany him. You'll be so excited that you'll make preparations for weeks beforehand. You'll ask me about coconuts and volcanoes and surfing, and practice hula dancing in the mirror. You'll pack a suitcase with the clothes and toys you want to bring, and you'll drag it around the house to see how long you can carry it. You'll ask me if I can carry your Etch-a-Sketch in my bag, since there won't be any more room for it in yours and you simply can't leave without it.

"You won't need all of these," I'll say. "There'll be so many fun things to do there, you won't have time to play with so many toys."

You'll consider that; dimples will appear above your eyebrows when you think hard. Eventually you'll agree to pack fewer toys, but your expectations will, if anything, increase.

"I wanna be in Hawaii now," you'll whine.

"Sometimes it's good to wait," I'll say. "The anticipation makes it more fun when you get there."

You'll just pout.

...

In the next report I submitted, I suggested that the term "logogram" was a misnomer because it implied that each graph represented a spoken word, when in fact the graphs didn't correspond to our notion of spoken words at all. I didn't want to use the term "ideogram" either because of how it had been used in the past; I suggested the term "semagram" instead.

It appeared that a semagram corresponded roughly to a written word in human languages: it was meaningful on its own, and in combination with other semagrams could form endless statements. We couldn't define it precisely, but then no one had ever satisfactorily defined "word" for human languages either. When it came to sentences in Heptapod B, though, things became much more confusing. The language had no written punctuation: its syntax was indicated in the way the semagrams were combined, and there was no need to indicate the cadence of speech. There was certainly no way to slice out subject-predicate pairings neatly to make sentences. A "sentence" seemed to be whatever number of semagrams a heptapod wanted to join together; the only difference between a sentence and a paragraph, or a page, was size.

When a Heptapod B sentence grew fairly sizable, its visual impact was remarkable. If I wasn't trying to decipher it, the writing looked like fanciful praying mantids drawn in a cursive style, all clinging to each other to form an Escheresque lattice, each slightly different in its stance. And the biggest sentences had an effect similar to that of psychedelic posters: sometimes eye-watering, sometimes hypnotic.

...

I remember a picture of you taken at your college graduation. In the photo you're striking a pose for the camera, mortarboard stylishly tilted on your head, one hand touching your sunglasses, the other hand on your hip, holding open your gown to reveal the tank top and shorts you're wearing underneath.

I remember your graduation. There will be the distraction of having Nelson and your father and what's-her-name there all at the same time, but that will be minor. That entire weekend, while you're introducing me to your classmates and hugging everyone incessantly, I'll be all but mute with amazement. I can't believe that you, a grown woman taller than me and beautiful enough to make my heart ache, will be the same girl I used to lift off the ground so you could reach the drinking fountain, the same girl who used to trundle out of my bedroom draped in a dress and hat and four scarves from my closet.

And after graduation, you'll be heading for a job as a financial analyst. I won't understand what you do there, I won't even understand your fascination with money, the preeminence you gave to salary when negotiating job offers. I would prefer it if you'd pursue something without regard for its monetary rewards, but I'll have no complaints. My own mother could never understand why I couldn't just be a high school English teacher. You'll do what makes you happy, and that'll be all I ask for.

• • •

As time went on, the teams at each looking glass began working in earnest on learning heptapod terminology for elementary mathematics and physics. We worked together on presentations, with the linguists focusing on procedure and the physicists focusing on subject matter. The physicists showed us previously devised systems for communicating with aliens, based on mathematics, but those were intended for use over a radio telescope. We reworked them for face-to-face communication.

Our teams were successful with basic arithmetic, but we hit a roadblock with geometry and algebra. We tried using a spherical coordinate system instead of a rectangular one, thinking it might be

more natural to the heptapods given their anatomy, but that approach wasn't any more fruitful. The heptapods didn't seem to understand what we were getting at.

Likewise, the physics discussions went poorly. Only with the most concrete terms, like the names of the elements, did we have any success; after several attempts at representing the periodic table, the heptapods got the idea. For anything remotely abstract, we might as well have been gibbering. We tried to demonstrate basic physical attributes like mass and acceleration so we could elicit their terms for them, but the heptapods simply responded with requests for clarification. To avoid perceptual problems that might be associated with any particular medium, we tried physical demonstrations as well as line drawings, photos, and animations; none were effective. Days with no progress became weeks, and the physicists were becoming disillusioned.

By contrast, the linguists were having much more success. We made steady progress decoding the grammar of the spoken language, Heptapod A. It didn't follow the pattern of human languages, as expected, but it was comprehensible so far: free word order, even to the extent that there was no preferred order for the clauses in a conditional statement, in defiance of a human language "universal." It also appeared that the heptapods had no objection to many levels of center-embedding of clauses, something that quickly defeated humans. Peculiar, but not impenetrable.

Much more interesting were the newly discovered morphological and grammatical processes in Heptapod B that were uniquely two-dimensional. Depending on a semagram's declension, inflections could be indicated by varying a certain stroke's curvature, or its thickness, or its manner of undulation; or by varying the relative sizes of two radicals, or their relative distance to another radical, or their orientations; or various other means. These were nonsegmental graphemes; they couldn't be isolated from the rest of a semagram. And despite how such traits behaved in human writing, these had

nothing to do with calligraphic style; their meanings were defined according to a consistent and unambiguous grammar.

We regularly asked the heptapods why they had come. Each time, they answered "to see," or "to observe." Indeed, sometimes they preferred to watch us silently rather than answer our questions. Perhaps they were scientists, perhaps they were tourists. The State Department instructed us to reveal as little as possible about humanity, in case that information could be used as a bargaining chip in subsequent negotiations. We obliged, though it didn't require much effort: the heptapods never asked questions about anything. Whether scientists or tourists, they were an awfully incurious bunch.

• • •

I remember once when we'll be driving to the mall to buy some new clothes for you. You'll be thirteen. One moment you'll be sprawled in your seat, completely unself-conscious, all child; the next, you'll toss your hair with a practiced casualness, like a fashion model in training.

You'll give me some instructions as I'm parking the car. "Okay, Mom, give me one of the credit cards, and we can meet back at the entrance here in two hours."

I'll laugh. "Not a chance. All the credit cards stay with me."

"You're kidding." You'll become the embodiment of exasperation. We'll get out of the car and I will start walking to the mall entrance. After seeing that I won't budge on the matter, you'll quickly reformulate your plans.

"Okay Mom, okay. You can come with me, just walk a little ways behind me, so it doesn't look like we're together. If I see any friends

of mine, I'm gonna stop and talk to them, but you just keep walking, okay? I'll come find you later."

I'll stop in my tracks. "Excuse me? I am not the hired help, nor am I some mutant relative for you to be ashamed of."

"But Mom, I can't let anyone see you with me."

"What are you talking about? I've already met your friends; they've been to the house."

"That was different," you'll say, incredulous that you have to explain it. "This is shopping."

"Too bad."

Then the explosion: "You won't do the least thing to make me happy! You don't care about me at all!"

It won't have been that long since you enjoyed going shopping with me; it will forever astonish me how quickly you grow out of one phase and enter another. Living with you will be like aiming for a moving target; you'll always be further along than I expect.

• • •

I looked at the sentence in Heptapod B that I had just written, using simple pen and paper. Like all the sentences I generated myself, this one looked misshapen, like a heptapod-written sentence that had been smashed with a hammer and then inexpertly taped back together. I had sheets of such inelegant semagrams covering my desk, fluttering occasionally when the oscillating fan swung past.

It was strange trying to learn a language that had no spoken form. Instead of practicing my pronunciation, I had taken to squeezing my

eyes shut and trying to paint semagrams on the insides of my eyelids.

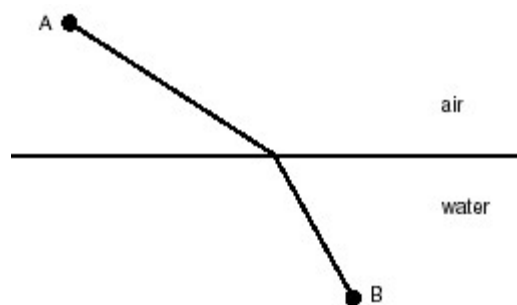
There was a knock at the door and before I could answer Gary came in looking jubilant. "Illinois got a repetition in physics."

"Really? That's great; when did it happen?"

"It happened a few hours ago; we just had the videoconference. Let me show you what it is." He started erasing my blackboard.

"Don't worry, I didn't need any of that."

"Good." He picked up a nub of chalk and drew a diagram:



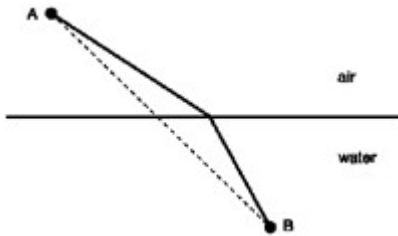
"Okay, here's the path a ray of light takes when crossing from air to water. The light ray travels in a straight line until it hits the water; the water has a different index of refraction, so the light changes direction. You've heard of this before, right?"

I nodded. "Sure." "Now here's an interesting property about the path the light takes. The path is the fastest possible route between these two points."

"Come again?"

"Imagine, just for grins, that the ray of light traveled along this path."

He added a dotted line to his diagram:

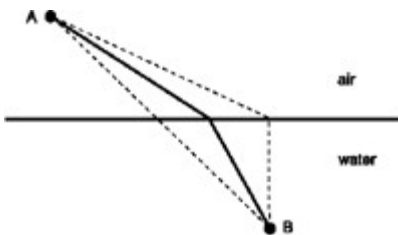


"This hypothetical path is shorter than the path the light actually takes. But light travels more slowly in water than it does in air, and a greater percentage of this path is underwater. So it would take longer for light to travel along this path than it does along the real path."

"Okay, I get it."

"Now imagine if light were to travel along this other path."

He drew a second dotted path:



"This path reduces the percentage that's underwater, but the total length is larger. It would also take longer for light to travel along this path than along the actual one."

Gary put down the chalk and gestured at the diagram on the chalkboard with white-tipped fingers. "Any hypothetical path would

require more time to traverse than the one actually taken. In other words, the route that the light ray takes is always the fastest possible one. That's Fermat's principle of least time."

"Hmm, interesting. And this is what the heptapods responded to?"

"Exactly. Moorehead gave an animated presentation of Fermat's principle at the Illinois looking glass, and the heptapods repeated it back. Now he's trying to get a symbolic description." He grinned. "Now is that highly neat, or what?"

"It's neat all right, but how come I haven't heard of Fermat's principle before?" I picked up a binder and waved it at him; it was a primer on the physics topics suggested for use in communication with the heptapods. "This thing goes on forever about Planck masses and the spin-flip of atomic hydrogen, and not a word about the refraction of light."

"We guessed wrong about what'd be most useful for you to know," Gary said without embarrassment. "In fact, it's curious that Fermat's principle was the first breakthrough; even though it's easy to explain, you need calculus to describe it mathematically. And not ordinary calculus; you need the calculus of variations. We thought that some simple theorem of geometry or algebra would be the breakthrough."

"Curious indeed. You think the heptapods' idea of what's simple doesn't match ours?"

"Exactly, which is why I'm *dying* to see what their mathematical description of Fermat's principle looks like." He paced as he talked. "If their version of the calculus of variations is simpler to them than their equivalent of algebra, that might explain why we've had so much trouble talking about physics; their entire system of mathematics may be topsy-turvy compared to ours." He pointed to the physics primer. "You can be sure that we're going to revise that."

"So can you build from Fermat's principle to other areas of physics?"

"Probably. There are lots of physical principles just like Fermat's."

"What, like Louise's principle of least closet space? When did physics become so minimalist?"

"Well, the word 'least' is misleading. You see, Fermat's principle of least time is incomplete; in certain situations light follows a path that takes *more* time than any of the other possibilities. It's more accurate to say that light always follows an *extreme* path, either one that minimizes the time taken or one that maximizes it. A minimum and a maximum share certain mathematical properties, so both situations can be described with one equation. So to be precise, Fermat's principle isn't a minimal principle; instead it's what's known as a 'variational' principle."

"And there are more of these variational principles?"

He nodded. "In all branches of physics. Almost every physical law can be restated as a variational principle. The only difference between these principles is in which attribute is minimized or maximized." He gestured as if the different branches of physics were arrayed before him on a table. "In optics, where Fermat's principle applies, time is the attribute that has to be an extreme. In mechanics, it's a different attribute. In electromagnetism, it's something else again. But all these principles are similar mathematically."

"So once you get their mathematical description of Fermat's principle, you should be able to decode the other ones."

"God, I hope so. I think this is the wedge that we've been looking for, the one that cracks open their formulation of physics. This calls for a celebration." He stopped his pacing and turned to me. "Hey Louise, want to go out for dinner? My treat."

I was mildly surprised. "Sure," I said.

...

It'll be when you first learn to walk that I get daily demonstrations of the asymmetry in our relationship. You'll be incessantly running off somewhere, and each time you walk into a door frame or scrape your knee, the pain feels like it's my own. It'll be like growing an errant limb, an extension of myself whose sensory nerves report pain just fine, but whose motor nerves don't convey my commands at all. It's so unfair: I'm going to give birth to an animated voodoo doll of myself. I didn't see this in the contract when I signed up. Was this part of the deal?

And then there will be the times when I see you laughing. Like the time you'll be playing with the neighbor's puppy, poking your hands through the chain-link fence separating our back yards, and you'll be laughing so hard you'll start hiccuping. The puppy will run inside the neighbor's house, and your laughter will gradually subside, letting you catch your breath. Then the puppy will come back to the fence to lick your fingers again, and you'll shriek and start laughing again. It will be the most wonderful sound I could ever imagine, a sound that makes me feel like a fountain, or a wellspring.

Now if only I can remember that sound the next time your blithe disregard for self-preservation gives me a heart attack.

...

After the breakthrough with Fermat's principle, discussions of scientific concepts became more fruitful. It wasn't as if all of heptapod physics were suddenly rendered transparent, but progress was steady. According to Gary, the heptapods' formulation of physics was indeed topsy-turvy relative to ours. Physical attributes that

humans defined using integral calculus were seen as fundamental by the heptapods. As an example, Gary described an attribute that, in physics jargon, bore the deceptively simple name "action," which represented "the difference between kinetic and potential energy, integrated over time," whatever that meant. Calculus for us; elementary to them.

Conversely, to define attributes that humans thought of as fundamental, like velocity, the heptapods employed mathematics that were, Gary assured me, "highly weird." The physicists were ultimately able to prove the equivalence of heptapod mathematics and human mathematics; even though their approaches were almost the reverse of one another, both were systems for describing the same physical universe.

I tried following some of the equations that the physicists were coming up with, but it was no use. I couldn't really grasp the significance of physical attributes like "action"; I couldn't, with any confidence, ponder the significance of treating such an attribute as fundamental. Still, I tried to ponder questions formulated in terms more familiar to me: what kind of worldview did the heptapods have, that they would consider Fermat's principle the simplest explanation of light refraction? What kind of perception made a minimum or maximum readily apparent to them?

...

Your eyes will be blue like your dad's, not mud brown like mine. Boys will stare into those eyes the way I did, and do, into your dad's, surprised and enchanted, as I was and am, to find them in combination with black hair. You will have many suitors.

I remember when you are fifteen, coming home after a weekend at your dad's, incredulous over the interrogation he'll have put you through regarding the boy you're currently dating. You'll sprawl on

the sofa, recounting your dad's latest breach of common sense: "You know what he said? He said, 'I know what teenage boys are like.'" Roll of the eyes. "Like I don't?"

"Don't hold it against him," I'll say. "He's a father; he can't help it." Having seen you interact with your friends, I won't worry much about a boy taking advantage of you; if anything, the opposite will be more likely. I'll worry about that.

"He wishes I were still a kid. He hasn't known how to act toward me since I grew breasts."

"Well, that development was a shock for him. Give him time to recover."

"It's been *years*, Mom. How long is it gonna take?"

"I'll let you know when my father has come to terms with mine."

• • •

During one of the videoconferences for the linguists, Cisneros from the Massachusetts looking glass had raised an interesting question: Was there a particular order in which semagrams were written in a Heptapod B sentence? It was clear that word order meant next to nothing when speaking in Heptapod A; when asked to repeat what it had just said, a heptapod would likely as not use a different word order unless we specifically asked them not to. Was word order similarly unimportant when writing in Heptapod B?

Previously, we had focused our attention only on how a sentence in Heptapod B looked once it was complete. As far as anyone could tell, there was no preferred order when reading the semagrams in a sentence; you could start almost anywhere in the nest, then follow

the branching clauses until you'd read the whole thing. But that was reading; was the same true about writing?

During my most recent session with Flapper and Raspberry I had asked them if, instead of displaying a semagram only after it was completed, they could show it to us while it was being written. They had agreed. I inserted the videotape of the session into the VCR, and on my computer I consulted the session transcript.

I picked one of the longer utterances from the conversation. What Flapper had said was that the heptapods' planet had two moons, one significantly larger than the other; the three primary constituents of the planet's atmosphere were nitrogen, argon, and oxygen; and 15/28ths of the planet's surface was covered by water. The first words of the spoken utterance translated literally as "inequality-of-size rocky-orbiter rockyorbiters related-as-primary-to-secondary."

Then I rewound the videotape until the time signature matched the one in the transcription. I started playing the tape, and watched the web of semagrams being spun out of inky spider's silk. I rewound it and played it several times. Finally I froze the video right after the first stroke was completed and before the second one was begun; all that was visible onscreen was a single sinuous line.

Comparing that initial stroke with the completed sentence, I realized that the stroke participated in several different clauses of the message. It began in the semagram for "oxygen," as the determinant that distinguished it from certain other elements; then it slid down to become the morpheme of comparison in the description of the two moons' sizes; and lastly it flared out as the arched backbone of the semagram for "ocean." Yet this stroke was a single continuous line, and it was the first one that Flapper wrote. That meant the heptapod had to know how the entire sentence would be laid out before it could write the very first stroke.

The other strokes in the sentence also traversed several clauses, making them so interconnected that none could be removed without

redesigning the entire sentence. The heptapods didn't write a sentence one semagram at a time; they built it out of strokes irrespective of individual semagrams. I had seen a similarly high degree of integration before in calligraphic designs, particularly those employing the Arabic alphabet. But those designs had required careful planning by expert calligraphers. No one could lay out such an intricate design at the speed needed for holding a conversation. At least, no human could.

• • •

There's a joke that I once heard a comedienne tell. It goes like this: "I'm not sure if I'm ready to have children. I asked a friend of mine who has children, 'Suppose I do have kids. What if when they grow up, they blame me for everything that's wrong with their lives?' She laughed and said, 'What do you mean, if?' "

That's my favorite joke.

• • •

Gary and I were at a little Chinese restaurant, one of the local places we had taken to patronizing to get away from the encampment. We sat eating the appetizers: potstickers, redolent of pork and sesame oil. My favorite.

I dipped one in soy sauce and vinegar. "So how are you doing with your Heptapod B practice?" I asked.

Gary looked obliquely at the ceiling. I tried to meet his gaze, but he kept shifting it.

"You've given up, haven't you?" I said. "You're not even trying anymore."

He did a wonderful hangdog expression. "I'm just no good at languages," he confessed. "I thought learning Heptapod B might be more like learning mathematics than trying to speak another language, but it's not. It's too foreign for me."

"It would help you discuss physics with them."

"Probably, but since we had our breakthrough, I can get by with just a few phrases."

I sighed. "I suppose that's fair; I have to admit, I've given up on trying to learn the mathematics."

"So we're even?"

"We're even." I sipped my tea. "Though I did want to ask you about Fermat's principle. Something about it feels odd to me, but I can't put my finger on it. It just doesn't sound like a law of physics."

A twinkle appeared in Gary's eyes. "I'll bet I know what you're talking about." He snipped a potsticker in half with his chopsticks. "You're used to thinking of refraction in terms of cause and effect: reaching the water's surface is the cause, and the change in direction is the effect. But Fermat's principle sounds weird because it describes light's behavior in goal-oriented terms. It sounds like a commandment to a light beam: 'Thou shalt minimize or maximize the time taken to reach thy destination.' "

I considered it. "Go on."

"It's an old question in the philosophy of physics. People have been talking about it since Fermat first formulated it in the 1600s; Planck wrote volumes about it. The thing is, while the common formulation

of physical laws is causal, a variational principle like Fermat's is purposive, almost teleological."

"Hmm, that's an interesting way to put it. Let me think about that for a minute." I pulled out a felt-tip pen and, on my paper napkin, drew a copy of the diagram that Gary had drawn on my blackboard. "Okay," I said, thinking aloud, "so let's say the goal of a ray of light is to take the fastest path. How does the light go about doing that?"

"Well, if I can speak anthropomorphic-projectively, the light has to examine the possible paths and compute how long each one would take." He plucked the last potsticker from the serving dish.

"And to do that," I continued, "the ray of light has to know just where its destination is. If the destination were somewhere else, the fastest path would be different."

Gary nodded again. "That's right; the notion of a 'fastest path' is meaningless unless there's a destination specified. And computing how long a given path takes also requires information about what lies along that path, like where the water's surface is."

I kept staring at the diagram on the napkin. "And the light ray has to know all that ahead of time, before it starts moving, right?"

"So to speak," said Gary. "The light can't start traveling in any old direction and make course corrections later on, because the path resulting from such behavior wouldn't be the fastest possible one. The light has to do all its computations at the very beginning."

I thought to myself, *the ray of light has to know where it will ultimately end up before it can choose the direction to begin moving in*. I knew what that reminded me of. I looked up at Gary. "That's what was bugging me."

...

I remember when you're fourteen. You'll come out of your bedroom, a graffiti-covered notebook computer in hand, working on a report for school.

"Mom, what do you call it when both sides can win?" I'll look up from my computer and the paper I'll be writing. "What, you mean a win-win situation?"

"There's some technical name for it, some math word. Remember that time Dad was here, and he was talking about the stock market? He used it then."

"Hmm, that sounds familiar, but I can't remember what he called it."

"I need to know. I want to use that phrase in my social studies report. I can't even search for information on it unless I know what it's called."

"I'm sorry, I don't know it either. Why don't you call your dad?"

Judging from your expression, that will be more effort than you want to make. At this point, you and your father won't be getting along well. "Can you call Dad and ask him? But don't tell him it's for me."

"I think you can call him yourself."

You'll fume, "Jesus, Mom, I can never get help with my homework since you and Dad split up."

It's amazing the diverse situations in which you can bring up the divorce. "I've helped you with your homework."

"Like a million years ago, Mom." I'll let that pass. "I'd help you with this if I could, but I don't remember what it's called."

You'll head back to your bedroom in a huff.

• • •

I practiced Heptapod B at every opportunity, both with the other linguists and by myself. The novelty of reading a semasiographic language made it compelling in a way that Heptapod A wasn't, and my improvement in writing it excited me. Over time, the sentences I wrote grew shapelier, more cohesive. I had reached the point where it worked better when I didn't think about it too much. Instead of carefully trying to design a sentence before writing, I could simply begin putting down strokes immediately; my initial strokes almost always turned out to be compatible with an elegant rendition of what I was trying to say. I was developing a faculty like that of the heptapods.

More interesting was the fact that Heptapod B was changing the way I thought. For me, thinking typically meant speaking in an internal voice; as we say in the trade, my thoughts were phonologically coded. My internal voice normally spoke in English, but that wasn't a requirement. The summer after my senior year in high school, I attended a total immersion program for learning Russian; by the end of the summer, I was thinking and even dreaming in Russian. But it was always *spoken* Russian. Different language, same mode: a voice speaking silently aloud.

The idea of thinking in a linguistic yet nonphonological mode always intrigued me. I had a friend born of Deaf parents; he grew up using American Sign Language, and he told me that he often thought in ASL instead of English. I used to wonder what it was like to have one's thoughts be manually coded, to reason using an inner pair of hands instead of an inner voice.

With Heptapod B, I was experiencing something just as foreign: my thoughts were becoming graphically coded. There were trance-like

moments during the day when my thoughts weren't expressed with my internal voice; instead, I saw semagrams with my mind's eye, sprouting like frost on a windowpane.

As I grew more fluent, semagraphic designs would appear fully formed, articulating even complex ideas all at once. My thought processes weren't moving any faster as a result, though. Instead of racing forward, my mind hung balanced on the symmetry underlying the semagrams. The semagrams seemed to be something more than language; they were almost like mandalas. I found myself in a meditative state, contemplating the way in which premises and conclusions were interchangeable. There was no direction inherent in the way propositions were connected, no "train of thought" moving along a particular route; all the components in an act of reasoning were equally powerful, all having identical precedence.

• • •

A representative from the State Department named Hossner had the job of briefing the U.S. scientists on our agenda with the heptapods. We sat in the videoconference room, listening to him lecture. Our microphone was turned off, so Gary and I could exchange comments without interrupting Hossner. As we listened, I worried that Gary might harm his vision, rolling his eyes so often.

"They must have had some reason for coming all this way," said the diplomat, his voice tinny through the speakers. "It does not look like their reason was conquest, thank God. But if that's not the reason, what is? Are they prospectors? Anthropologists? Missionaries? Whatever their motives, there must be something we can offer them. Maybe it's mineral rights to our solar system. Maybe it's information about ourselves. Maybe it's the right to deliver sermons to our populations. But we can be sure that there's something.

"My point is this: their motive might not be to trade, but that doesn't mean that we cannot conduct trade. We simply need to know why they're here, and what we have that they want. Once we have that information, we can begin trade negotiations.

"I should emphasize that our relationship with the heptapods need not be adversarial. This is not a situation where every gain on their part is a loss on ours, or vice versa. If we handle ourselves correctly, both we and the heptapods can come out winners."

"You mean it's a non-zero-sum game?" Gary said in mock incredulity. "Oh my gosh."

• • •

"A non-zero-sum game."

"What?" You'll reverse course, heading back from your bedroom.

"When both sides can win: I just remembered, it's called a non-zero-sum game."

"That's it!" you'll say, writing it down on your notebook. "Thanks, Mom!"

"I guess I knew it after all," I'll say. "All those years with your father, some of it must have rubbed off."

"I knew you'd know it," you'll say. You'll give me a sudden, brief hug, and your hair will smell of apples. "You're the best."

• • •

"Louise?"

"Hmm? Sorry, I was distracted. What did you say?"

"I said, what do you think about our Mr. Hossner here?"

"I prefer not to."

"I've tried that myself: ignoring the government, seeing if it would go away. It hasn't."

As evidence of Gary's assertion, Hossner kept blathering: "Your immediate task is to think back on what you've learned. Look for anything that might help us. Has there been any indication of what the heptapods want? Of what they value?"

"Gee, it never occurred to us to look for things like that," I said. "We'll get right on it, sir."

"The sad thing is, that's just what we'll have to do," said Gary.

"Are there any questions?" asked Hossner.

Burghart, the linguist at the Ft. Worth looking glass, spoke up. "We've been through this with the heptapods many times. They maintain that they're here to observe, and they maintain that information is not tradable."

"So they would have us believe," said Hossner. "But consider: how could that be true? I know that the heptapods have occasionally stopped talking to us for brief periods. That may be a tactical maneuver on their part. If we were to stop talking to them tomorrow —"

"Wake me up if he says something interesting," said Gary.

"I was just going to ask you to do the same for me."

...

That day when Gary first explained Fermat's principle to me, he had mentioned that almost every physical law could be stated as a variational principle. Yet when humans thought about physical laws, they preferred to work with them in their causal formulation. I could understand that: the physical attributes that humans found intuitive, like kinetic energy or acceleration, were all properties of an object at a given moment in time. And these were conducive to a chronological, causal interpretation of events: one moment growing out of another, causes and effects creating a chain reaction that grew from past to future.

In contrast, the physical attributes that the heptapods found intuitive, like "action" or those other things defined by integrals, were meaningful only over a period of time. And these were conducive to a teleological interpretation of events: by viewing events over a period of time, one recognized that there was a requirement that had to be satisfied, a goal of minimizing or maximizing. And one had to know the initial and final states to meet that goal; one needed knowledge of the effects before the causes could be initiated.

I was growing to understand that, too.

...

"Why?" you'll ask again. You'll be three.

"Because it's your bedtime," I'll say again. We'll have gotten as far as getting you bathed and into your jammies, but no further than that.

"But I'm not sleepy," you'll whine. You'll be standing at the bookshelf, pulling down a video to watch: your latest diversionary tactic to keep away from your bedroom.

"It doesn't matter: you still have to go to bed."

"But why?"

"Because I'm the mom and I said so."

I'm actually going to say that, aren't I? God, somebody please shoot me.

I'll pick you up and carry you under my arm to your bed, you wailing piteously all the while, but my sole concern will be my own distress. All those vows made in childhood that I would give reasonable answers when I became a parent, that I would treat my own child as an intelligent, thinking individual, all for naught: I'm going to turn into my mother. I can fight it as much as I want, but there'll be no stopping my slide down that long, dreadful slope.

• • •

Was it actually possible to know the future? Not simply to guess at it; was it possible to *know* what was going to happen, with absolute certainty and in specific detail? Gary once told me that the fundamental laws of physics were time-symmetric, that there was no physical difference between past and future. Given that, some might say, "yes, theoretically." But speaking more concretely, most would answer "no," because of free will.

I liked to imagine the objection as a Borgesian fabulation: consider a person standing before the *Book of Ages*, the chronicle that records every event, past and future. Even though the text has been photoreduced from the full-sized edition, the volume is enormous.

With magnifier in hand, she flips through the tissue-thin leaves until she locates the story of her life. She finds the passage that describes her flipping through the *Book of Ages*, and she skips to the next column, where it details what she'll be doing later in the day: acting on information she's read in the *Book*, she'll bet \$100 on the racehorse Devil May Care and win twenty times that much.

The thought of doing just that had crossed her mind, but being a contrary sort, she now resolves to refrain from betting on the ponies altogether.

There's the rub. The *Book of Ages* cannot be wrong; this scenario is based on the premise that a person is given knowledge of the actual future, not of some possible future. If this were Greek myth, circumstances would conspire to make her enact her fate despite her best efforts, but prophecies in myth are notoriously vague; the *Book of Ages* is quite specific, and there's no way she can be forced to bet on a racehorse in the manner specified. The result is a contradiction: the *Book of Ages* must be right, by definition; yet no matter what the *Book* says she'll do, she can choose to do otherwise. How can these two facts be reconciled?

They can't be, was the common answer. A volume like the *Book of Ages* is a logical impossibility, for the precise reason that its existence would result in the above contradiction. Or, to be generous, some might say that the *Book of Ages* could exist, as long as it wasn't accessible to readers: that volume is housed in a special collection, and no one has viewing privileges.

The existence of free will meant that we couldn't know the future. And we knew free will existed because we had direct experience of it. Volition was an intrinsic part of consciousness.

Or was it? What if the experience of knowing the future changed a person? What if it evoked a sense of urgency, a sense of obligation to act precisely as she knew she would?

• • •

I stopped by Gary's office before leaving for the day. "I'm calling it quits. Did you want to grab something to eat?"

"Sure, just wait a second," he said. He shut down his computer and gathered some papers together. Then he looked up at me. "Hey, want to come to my place for dinner tonight? I'll cook."

I looked at him dubiously. "You can cook?"

"Just one dish," he admitted. "But it's a good one."

"Sure," I said. "I'm game."

"Great. We just need to go shopping for the ingredients."

"Don't go to any trouble—"

"There's a market on the way to my house. It won't take a minute."

We took separate cars, me following him. I almost lost him when he abruptly turned into a parking lot. It was a gourmet market, not large, but fancy; tall glass jars stuffed with imported foods sat next to specialty utensils on the store's stainless-steel shelves.

I accompanied Gary as he collected fresh basil, tomatoes, garlic, linguini. "There's a fish market next door; we can get fresh clams there," he said.

"Sounds good." We walked past the section of kitchen utensils. My gaze wandered over the shelves— pepper mills, garlic presses, salad tongs— and stopped on a wooden salad bowl.

When you are three, you'll pull a dishtowel off the kitchen counter and bring that salad bowl down on top of you. I'll make a grab for it, but I'll miss. The edge of the bowl will leave you with a cut, on the upper edge of your forehead, that will require a single stitch. Your father and I will hold you, sobbing and stained with Caesar dressing, as we wait in the emergency room for hours.

I reached out and took the bowl from the shelf. The motion didn't feel like something I was forced to do. Instead it seemed just as urgent as my rushing to catch the bowl when it falls on you: an instinct that I felt right in following.

"I could use a salad bowl like this."

Gary looked at the bowl and nodded approvingly. "See, wasn't it a good thing that I had to stop at the market?"

"Yes it was." We got in line to pay for our purchases.

• • •

Consider the sentence "The rabbit is ready to eat." Interpret "rabbit" to be the object of "eat," and the sentence was an announcement that dinner would be served shortly. Interpret "rabbit" to be the subject of "eat," and it was a hint, such as a young girl might give her mother so she'll open a bag of Purina Bunny Chow. Two very different utterances; in fact, they were probably mutually exclusive within a single household. Yet either was a valid interpretation; only context could determine what the sentence meant.

Consider the phenomenon of light hitting water at one angle, and traveling through it at a different angle. Explain it by saying that a difference in the index of refraction caused the light to change direction, and one saw the world as humans saw it. Explain it by saying that light minimized the time needed to travel to its

destination, and one saw the world as the heptapods saw it. Two very different interpretations.

The physical universe was a language with a perfectly ambiguous grammar. Every physical event was an utterance that could be parsed in two entirely different ways, one causal and the other teleological, both valid, neither one disqualifiable no matter how much context was available.

When the ancestors of humans and heptapods first acquired the spark of consciousness, they both perceived the same physical world, but they parsed their perceptions differently; the worldviews that ultimately arose were the end result of that divergence. Humans had developed a sequential mode of awareness, while heptapods had developed a simultaneous mode of awareness. We experienced events in an order, and perceived their relationship as cause and effect. They experienced all events at once, and perceived a purpose underlying them all. A minimizing, maximizing purpose.

• • •

I have a recurring dream about your death. In the dream, I'm the one who's rock climbing— me, can you imagine it?— and you're three years old, riding in some kind of backpack I'm wearing. We're just a few feet below a ledge where we can rest, and you won't wait until I've climbed up to it. You start pulling yourself out of the pack; I order you to stop, but of course you ignore me. I feel your weight alternating from one side of the pack to the other as you climb out; then I feel your left foot on my shoulder, and then your right. I'm screaming at you, but I can't get a hand free to grab you. I can see the wavy design on the soles of your sneakers as you climb, and then I see a flake of stone give way beneath one of them. You slide right past me, and I can't move a muscle. I look down and see you shrink into the distance below me.

Then, all of a sudden, I'm at the morgue. An orderly lifts the sheet from your face, and I see that you're twenty-five.

"You okay?"

I was sitting upright in bed; I'd woken Gary with my movements. "I'm fine. I was just startled; I didn't recognize where I was for a moment."

Sleepily, he said, "We can stay at your place next time."

I kissed him. "Don't worry; your place is fine." We curled up, my back against his chest, and went back to sleep.

• • •

When you're three and we're climbing a steep, spiral flight of stairs, I'll hold your hand extra tightly. You'll pull your hand away from me. "I can do it by myself," you'll insist, and then move away from me to prove it, and I'll remember that dream. We'll repeat that scene countless times during your childhood. I can almost believe that, given your contrary nature, my attempts to protect you will be what create your love of climbing: first the jungle gym at the playground, then trees out in the green belt around our neighborhood, the rock walls at the climbing club, and ultimately cliff faces in national parks.

• • •

I finished the last radical in the sentence, put down the chalk, and sat down in my desk chair. I leaned back and surveyed the giant Heptapod B sentence I'd written that covered the entire blackboard in my office. It included several complex clauses, and I had managed to integrate all of them rather nicely.

Looking at a sentence like this one, I understood why the heptapods had evolved a semasiographic writing system like Heptapod B; it was better suited for a species with a simultaneous mode of consciousness. For them, speech was a bottleneck because it required that one word follow another sequentially. With writing, on the other hand, every mark on a page was visible simultaneously. Why constrain writing with a glottographic straitjacket, demanding that it be just as sequential as speech? It would never occur to them. Semasiographic writing naturally took advantage of the page's two-dimensionality; instead of doling out morphemes one at a time, it offered an entire page full of them all at once.

And now that Heptapod B had introduced me to a simultaneous mode of consciousness, I understood the rationale behind Heptapod A's grammar: what my sequential mind had perceived as unnecessarily convoluted, I now recognized as an attempt to provide flexibility within the confines of sequential speech. I could use Heptapod A more easily as a result, though it was still a poor substitute for Heptapod B.

There was a knock at the door and then Gary poked his head in. "Colonel Weber'll be here any minute."

I grimaced. "Right." Weber was coming to participate in a session with Flapper and Raspberry; I was to act as translator, a job I wasn't trained for and that I detested.

Gary stepped inside and closed the door. He pulled me out of my chair and kissed me.

I smiled. "You trying to cheer me up before he gets here?"

"No, I'm trying to cheer me up."

"You weren't interested in talking to the heptapods at all, were you? You worked on this project just to get me into bed."

"Ah, you see right through me."

I looked into his eyes. "You better believe it," I said.

• • •

I remember when you'll be a month old, and I'll stumble out of bed to give you your 2:00 a.m. feeding. Your nursery will have that "baby smell" of diaper rash cream and talcum powder, with a faint ammoniac whiff coming from the diaper pail in the corner. I'll lean over your crib, lift your squalling form out, and sit in the rocking chair to nurse you.

The word "infant" is derived from the Latin word for "unable to speak," but you'll be perfectly capable of saying one thing: "I suffer," and you'll do it tirelessly and without hesitation. I have to admire your utter commitment to that statement; when you cry, you'll become outrage incarnate, every fiber of your body employed in expressing that emotion. It's funny: when you're tranquil, you will seem to radiate light, and if someone were to paint a portrait of you like that, I'd insist that they include the halo. But when you're unhappy, you will become a klaxon, built for radiating sound; a portrait of you then could simply be a fire alarm bell.

At that stage of your life, there'll be no past or future for you; until I give you my breast, you'll have no memory of contentment in the past nor expectation of relief in the future. Once you begin nursing, everything will reverse, and all will be right with the world. NOW is the only moment you'll perceive; you'll live in the present tense. In many ways, it's an enviable state.

• • •

The heptapods are neither free nor bound as we understand those concepts; they don't act according to their will, nor are they helpless automatons. What distinguishes the heptapods' mode of awareness is not just that their actions coincide with history's events; it is also that their motives coincide with history's purposes. They act to create the future, to enact chronology.

Freedom isn't an illusion; it's perfectly real in the context of sequential consciousness. Within the context of simultaneous consciousness, freedom is not meaningful, but neither is coercion; it's simply a different context, no more or less valid than the other. It's like that famous optical illusion, the drawing of either an elegant young woman, face turned away from the viewer, or a wart-nosed crone, chin tucked down on her chest. There's no "correct" interpretation; both are equally valid. But you can't see both at the same time.

Similarly, knowledge of the future was incompatible with free will. What made it possible for me to exercise freedom of choice also made it impossible for me to know the future. Conversely, now that I know the future, I would never act contrary to that future, including telling others what I know: those who know the future don't talk about it. Those who've read the *Book of Ages* never admit to it.

• • •

I turned on the VCR and slotted a cassette of a session from the Ft. Worth looking glass. A diplomatic negotiator was having a discussion with the heptapods there, with Burghart acting as translator.

The negotiator was describing humans' moral beliefs, trying to lay some groundwork for the concept of altruism. I knew the heptapods were familiar with the conversation's eventual outcome, but they still participated enthusiastically.

If I could have described this to someone who didn't already know, she might ask, if the heptapods already knew everything that they would ever say or hear, what was the point of their using language at all? A reasonable question. But language wasn't only for communication: it was also a form of action. According to speech act theory, statements like "You're under arrest," "I christen this vessel," or "I promise" were all performative: a speaker could perform the action only by uttering the words. For such acts, knowing what would be said didn't change anything. Everyone at a wedding anticipated the words "I now pronounce you husband and wife," but until the minister actually said them, the ceremony didn't count. With performative language, saying equaled doing.

For the heptapods, all language was performative. Instead of using language to inform, they used language to actualize. Sure, heptapods already knew what would be said in any conversation; but in order for their knowledge to be true, the conversation would have to take place.

...

"First Goldilocks tried the papa bear's bowl of porridge, but it was full of Brussels sprouts, which she hated."

You'll laugh. "No, that's wrong!" We'll be sitting side by side on the sofa, the skinny, overpriced hardcover spread open on our laps.

I'll keep reading. "Then Goldilocks tried the mama bear's bowl of porridge, but it was full of spinach, which she also hated."

You'll put your hand on the page of the book to stop me. "You have to read it the right way!"

"I'm reading just what it says here," I'll say, all innocence.

"No you're not. That's not how the story goes."

"Well if you already know how the story goes, why do you need me to read it to you?"

" 'Cause I wanna hear it!"

• • •

The air-conditioning in Weber's office almost compensated for having to talk to the man.

"They're willing to engage in a type of exchange," I explained, "but it's not trade. We simply give them something, and they give us something in return. Neither party tells the other what they're giving beforehand."

Colonel Weber's brow furrowed just slightly. "You mean they're willing to exchange gifts?"

I knew what I had to say. "We shouldn't think of it as 'gift-giving.' We don't know if this transaction has the same associations for the heptapods that gift-giving has for us."

"Can we"— he searched for the right wording— "drop hints about the kind of gift we want?"

"They don't do that themselves for this type of transaction. I asked them if we could make a request, and they said we could, but it won't make them tell us what they're giving." I suddenly remembered that a morphological relative of "performative" was "performance," which could describe the sensation of conversing when you knew what would be said: it was like performing in a play.

"But would it make them more likely to give us what we asked for?" Colonel Weber asked. He was perfectly oblivious of the script, yet his responses matched his assigned lines exactly.

"No way of knowing," I said. "I doubt it, given that it's not a custom they engage in."

"If we give our gift first, will the value of our gift influence the value of theirs?" He was improvising, while I had carefully rehearsed for this one and only show.

"No," I said. "As far as we can tell, the value of the exchanged items is irrelevant."

"If only my relatives felt that way," murmured Gary wryly.

I watched Colonel Weber turn to Gary. "Have you discovered anything new in the physics discussions?" he asked, right on cue.

"If you mean, any information new to mankind, no," said Gary. "The heptapods haven't varied from the routine. If we demonstrate something to them, they'll show us their formulation of it, but they won't volunteer anything and they won't answer our questions about what they know."

An utterance that was spontaneous and communicative in the context of human discourse became a ritual recitation when viewed by the light of Heptapod B.

Weber scowled. "All right then, we'll see how the State Department feels about this. Maybe we can arrange some kind of gift-giving ceremony."

Like physical events, with their causal and teleological interpretations, every linguistic event had two possible interpretations: as a transmission of information and as the realization of a plan.

"I think that's a good idea, Colonel," I said.

It was an ambiguity invisible to most. A private joke; don't ask me to explain it.

• • •

Even though I'm proficient with Heptapod B, I know I don't experience reality the way a heptapod does. My mind was cast in the mold of human, sequential languages, and no amount of immersion in an alien language can completely reshape it. My worldview is an amalgam of human and heptapod.

Before I learned how to think in Heptapod B, my memories grew like a column of cigarette ash, laid down by the infinitesimal sliver of combustion that was my consciousness, marking the sequential present. After I learned Heptapod B, new memories fell into place like gigantic blocks, each one measuring years in duration, and though they didn't arrive in order or land contiguously, they soon composed a period of five decades. It is the period during which I know Heptapod B well enough to think in it, starting during my interviews with Flapper and Raspberry and ending with my death.

Usually, Heptapod B affects just my memory: my consciousness crawls along as it did before, a glowing sliver crawling forward in time, the difference being that the ash of memory lies ahead as well as behind: there is no real combustion. But occasionally I have glimpses when Heptapod B truly reigns, and I experience past and future all at once; my consciousness becomes a half-century-long ember burning outside time. I perceive— during those glimpses— that entire epoch as a simultaneity. It's a period encompassing the rest of my life, and the entirety of yours.

...

I wrote out the semagrams for "process create-endpoint inclusive-we," meaning "let's start." Raspberry replied in the affirmative, and the slide shows began. The second display screen that the heptapods had provided began presenting a series of images, composed of semagrams and equations, while one of our video screens did the same.

This was the second "gift exchange" I had been present for, the eighth one overall, and I knew it would be the last. The looking glass tent was crowded with people; Burghart from Ft. Worth was here, as were Gary and a nuclear physicist, assorted biologists, anthropologists, military brass, and diplomats. Thankfully they had set up an air conditioner to cool the place off. We would review the tapes of the images later to figure out just what the heptapods' "gift" was. Our own "gift" was a presentation on the Lascaux cave paintings.

We all crowded around the heptapods' second screen, trying to glean some idea of the images' content as they went by. "Preliminary assessments?" asked Colonel Weber.

"It's not a return," said Burghart. In a previous exchange, the heptapods had given us information about ourselves that we had previously told them. This had infuriated the State Department, but we had no reason to think of it as an insult: it probably indicated that trade value really didn't play a role in these exchanges. It didn't exclude the possibility that the heptapods might yet offer us a space drive, or cold fusion, or some other wish-fulfilling miracle.

"That looks like inorganic chemistry," said the nuclear physicist, pointing at an equation before the image was replaced.

Gary nodded. "It could be materials technology," he said.

"Maybe we're finally getting somewhere," said Colonel Weber.

"I wanna see more animal pictures," I whispered, quietly so that only Gary could hear me, and pouted like a child. He smiled and poked me. Truthfully, I wished the heptapods had given another xenobiology lecture, as they had on two previous exchanges; judging from those, humans were more similar to the heptapods than any other species they'd ever encountered. Or another lecture on heptapod history; those had been filled with apparent non sequiturs, but were interesting nonetheless. I didn't want the heptapods to give us new technology, because I didn't want to see what our governments might do with it.

I watched Raspberry while the information was being exchanged, looking for any anomalous behavior. It stood barely moving as usual; I saw no indications of what would happen shortly.

After a minute, the heptapod's screen went blank, and a minute after that, ours did too. Gary and most of the other scientists clustered around a tiny video screen that was replaying the heptapods' presentation. I could hear them talk about the need to call in a solid-state physicist.

Colonel Weber turned. "You two," he said, pointing to me and then to Burghart, "schedule the time and location for the next exchange." Then he followed the others to the playback screen.

"Coming right up," I said. To Burghart, I asked, "Would you care to do the honors, or shall I?"

I knew Burghart had gained a proficiency in Heptapod B similar to mine. "It's your looking glass," he said. "You drive."

I sat down again at the transmitting computer. "Bet you never figured you'd wind up working as an Army translator back when you were a grad student."

"That's for goddamn sure," he said. "Even now I can hardly believe it." Everything we said to each other felt like the carefully bland exchanges of spies who meet in public, but never break cover.

I wrote out the semagrams for "locus exchange-transaction converse inclusive-we" with the projective aspect modulation.

Raspberry wrote its reply. That was my cue to frown, and for Burghart to ask, "What does it mean by that?" His delivery was perfect.

I wrote a request for clarification; Raspberry's reply was the same as before. Then I watched it glide out of the room. The curtain was about to fall on this act of our performance.

Colonel Weber stepped forward. "What's going on? Where did it go?"

"It said that the heptapods are leaving now," I said. "Not just itself; all of them."

"Call it back here now. Ask it what it means."

"Um, I don't think Raspberry's wearing a pager," I said. The image of the room in the looking glass disappeared so abruptly that it took a moment for my eyes to register what I was seeing instead: it was the other side of the looking-glass tent. The looking glass had become completely transparent. The conversation around the playback screen fell silent.

"What the hell is going on here?" said Colonel Weber.

Gary walked up to the looking glass, and then around it to the other side. He touched the rear surface with one hand; I could see the pale ovals where his fingertips made contact with the looking glass. "I think," he said, "we just saw a demonstration of transmutation at a distance."

I heard the sounds of heavy footfalls on dry grass. A soldier came in through the tent door, short of breath from sprinting, holding an oversize walkie-talkie. "Colonel, message from—"

Weber grabbed the walkie-talkie from him.

• • •

I remember what it'll be like watching you when you are a day old. Your father will have gone for a quick visit to the hospital cafeteria, and you'll be lying in your bassinet, and I'll be leaning over you.

So soon after the delivery, I will still be feeling like a wrung-out towel. You will seem incongruously tiny, given how enormous I felt during the pregnancy; I could swear there was room for someone much larger and more robust than you in there. Your hands and feet will be long and thin, not chubby yet. Your face will still be all red and pinched, puffy eyelids squeezed shut, the gnomelike phase that precedes the cherubic.

I'll run a finger over your belly, marveling at the uncanny softness of your skin, wondering if silk would abrade your body like burlap. Then you'll writhe, twisting your body while poking out your legs one at a time, and I'll recognize the gesture as one I had felt you do inside me, many times. So *that's* what it looks like.

I'll feel elated at this evidence of a unique mother-child bond, this certitude that you're the one I carried. Even if I had never laid eyes on you before, I'd be able to pick you out from a sea of babies: Not that one. No, not her either. Wait, that one over there.

Yes, that's her. She's mine.

• • •

That final "gift exchange" was the last we ever saw of the heptapods. All at once, all over the world, their looking glasses became transparent and their ships left orbit. Subsequent analysis of the looking glasses revealed them to be nothing more than sheets of fused silica, completely inert. The information from the final exchange session described a new class of super-conducting materials, but it later proved to duplicate the results of research just completed in Japan: nothing that humans didn't already know.

We never did learn why the heptapods left, any more than we learned what brought them here, or why they acted the way they did. My own new awareness didn't provide that type of knowledge; the heptapods' behavior was presumably explicable from a sequential point of view, but we never found that explanation.

I would have liked to experience more of the heptapods' worldview, to feel the way they feel. Then, perhaps I could immerse myself fully in the necessity of events, as they must, instead of merely wading in its surf for the rest of my life. But that will never come to pass. I will continue to practice the heptapod languages, as will the other linguists on the looking glass teams, but none of us will ever progress any further than we did when the heptapods were here.

Working with the heptapods changed my life. I met your father and learned Heptapod B, both of which make it possible for me to know you now, here on the patio in the moonlight. Eventually, many years from now, I'll be without your father, and without you. All I will have left from this moment is the heptapod language. So I pay close attention, and note every detail.

From the beginning I knew my destination, and I chose my route accordingly. But am I working toward an extreme of joy, or of pain? Will I achieve a minimum, or a maximum?

These questions are in my mind when your father asks me, "Do you want to make a baby?" And I smile and answer, "Yes," and I unwrap his arms from around me, and we hold hands as we walk inside to make love, to make you.

Acknowledgments

Thanks to Michelle for being my sister, and thanks to my parents, Fu-Pen and Charlotte, for their sacrifices.

Thanks to the participants of Clarion, Acme Rhetoric, and Sycamore Hill for letting me work with them. Thanks to Tom Disch for the visit, Spider Robinson for the phone call, Damon Knight and Kate Wilhelm for the guidance, Karen Fowler for the anecdotes, and John Crowley for reopening my eyes. Thanks to Larret Galasyn-Wright for encouragement when I needed it and Danny Krashin for lending me his mind. Thanks to Alan Kaplan for all the conversations.

Thanks to Patrick Nielsen Hayden for taking a chance on this book. Thanks to everyone

Thanks to Juliet Albertson for love. And thanks to Marcia Glover, for love.

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